SAFETYSENSE LEAFLET 13
COLLISION AVOIDANCE

1 INTRODUCTION

a) 'See-and-avoid' is recognised as the main method that a pilot uses to minimise the risk of collision when flying in visual meteorological conditions. 'See-and-avoid' is directly linked with a pilot's skill at looking outside the cockpit or flight deck and becoming aware of what is happening in his/her surrounding. Its effectiveness can be greatly improved if the pilot can acquire skills to compensate for the limitations of the human eye. These skills include the application of:

- effective visual scanning;
- the ability to listen selectively to radio transmissions from ground stations and other aircraft;
- creating a mental picture of the traffic situation; and
- the development of 'good airmanship'.

b) This Leaflet, based on ICAO Circular 213–AN/130, aims to help pilots to make 'look-out' more effective and is mainly for pilots who do most of their flying under Visual Flight Rules (VFR). It should be of interest to all pilots, however, regardless of the type of aircraft they fly and the flight rules under which they operate since no pilot is immune to collisions.

c) A study of over two hundred reports of mid-air collisions in the US and Canada showed that they can occur in all phases of flight and at all altitudes. However, nearly all mid-air collisions occur in daylight and in excellent visual meteorological conditions, mostly at lower altitudes where most VFR flying is carried out. Because of the concentration of aircraft close to aerodromes, most collisions occurred near aerodromes when one or both aircraft were descending or climbing, and often within the circuit pattern. Although some aircraft were operating as Instrument Flight Rules (IFR) flights, most were VFR.

d) The pilots involved in the collisions ranged in experience from first solo to 15,000 hours, and the types of flight were equally varied. In one case a private pilot flying cross-country, legally VFR, in a single-engine aircraft collided with a turboprop aircraft under IFR control flown by two experienced airline pilots. In another case, a 7,000-hour commercial pilot on private business in a twin-engine aircraft overtook a single-engine aircraft on its final approach piloted by a young instructor giving dual instruction to a student pilot. Two commercial pilots, each with well over 1,000 hours, collided while ferrying a pair of new single-engine aircraft.

e) Experienced or inexperienced pilots can be involved in a mid-air collision. While a novice pilot has much to think about and so may forget to maintain an adequate look-out, the experienced pilot, having flown many hours of routine flight without spotting any hazardous traffic, may grow complacent and forget to scan.

f) There appears to be little difference in mid-air collision risk between high-wing and low-wing aircraft.

g) If you learn to use your eyes and maintain vigilance, you can reduce the risk of mid-air collisions. Studies show that there are certain definite warning patterns.

2 MID-AIR COLLISION CAUSES

a) What contributes to mid-air collisions? Undoubtedly, traffic congestion and aircraft speeds are part of the problem. In the head-on situation, for instance, a jet and a light twin-engine aircraft may have a closing speed of about 650 kt. It takes a minimum of 10 seconds for a pilot to spot traffic, identify it, realise it is a collision risk, react, and have the aircraft respond. But two aircraft converging at 650 kt could be less than 10 seconds apart when the pilots are first **able** to see each other! Furthermore, the field of view from the flight deck of a large aircraft can be more restricted than that from the cockpit of a small aircraft.

b) In addition, some air traffic control and radar facilities are overloaded or limited by terrain or weather. Thus they may not be able to offer the service you require.

c) These factors are all contributory causes, but the reason most often noted in the mid-air collision statistics reads 'failure of pilot to see other aircraft in time' — i.e. failure of the see-and-avoid system. In most cases at least one of the pilots involved could have seen the other aircraft in time to avoid the collision if that pilot had been watching properly. Therefore, it could be said that it is really a pilot’s vision which is the leading contributor to mid-air collisions. Take a look at how its limitations affect you.

3 LIMITATIONS OF VISION

a) The human eye is a very complex system. Its function is to receive images and transmit them to the brain for recognition and storage. About 80 per cent of our total information intake is through the eyes, thus the eye is our prime means of identifying what is going on around us.

b) In the air we depend on our eyes to provide most of the basic input necessary for flying the aircraft, e.g. attitude, speed, direction and proximity to opposing traffic. As air traffic density and aircraft closing speeds increase, the problem of mid-air collision increases considerably, and so does the importance of effective scanning. A basic understanding of the eyes' limitations in target detection is one of the best insurances a pilot can have against collision.

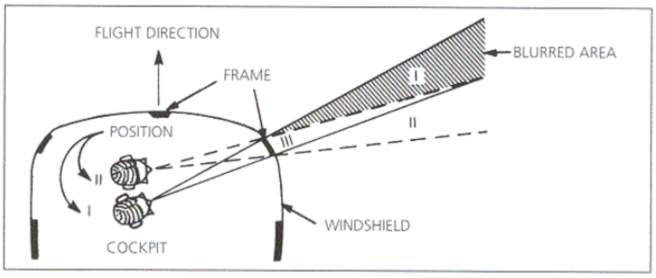
c) The eye, and consequently vision, is vulnerable to many things including dust, fatigue, emotion, germs, fallen eyelashes, age, optical illusions, and the effect of alcohol and certain medications. In flight, vision is influenced by atmospheric conditions, glare, lighting, windshield deterioration and distortion, aircraft design, cabin temperature, oxygen supply (particularly at night), acceleration forces and so forth. If you need glasses to correct your vision, even if not required to pass an aviation medical, make sure that you have regular checks that the prescription is still correct and that you carry any required second pair.

d) Most importantly, vision is vulnerable to the vagaries of the mind. We can 'see' and identify only what the mind permits us to see. A daydreaming pilot staring out into space is probably the prime candidate for a mid-air collision.

e) One inherent problem with the eye is the time required for accommodation or refocusing. Our eyes automatically accommodate for near and far objects, but the change from something up close, like a dark instrument panel two feet away, to a bright landmark or aircraft a mile or so away takes one to two seconds. That can be a long time when you consider that you need 10 seconds to avoid a mid-air collision.

f) Another focusing problem usually occurs when there is nothing to specifically focus on, which happens at very high altitudes, as well as at lower levels on vague, colourless days above a haze or cloud layer with no distinct horizon. People experience something known as 'empty-field myopia', i.e. staring but seeing nothing, not even opposing traffic entering their visual field.

g) To accept what we see, we need to receive cues from **both eyes** (binocular vision). If an object is visible to only one eye, but hidden from the other by a windshield post or other obstruction, the total image is blurred and not always acceptable to the mind. Therefore, it is essential that pilots move their heads when scanning around obstructions.



h) Another inherent eye problem is the narrow field of vision. Although our eyes accept light rays from an arc of nearly 200°, they are limited to a relatively narrow area (approximately 10–15°) in which they can actually focus on and classify an object. Although movement on the periphery can be perceived, we cannot identify what is happening there, and we tend not to believe what we see out of the corner of our eyes. This, aided by the brain, often leads to 'tunnel vision'.

i) Motion or contrast is needed to attract the eyes' attention, and the tunnel vision limitation can be compounded by the fact that at a distance **an aircraft on a collision course will appear to be motionless**. The aircraft will remain in a seemingly stationary position, without appearing to grow in size, for a relatively long time, and then **suddenly** bloom into a huge mass, almost filling up one of the windows. This is known as the 'blossom effect'. It is frightening that a large insect smear or dirty spot on the windshield can hide a converging aircraft until it is too close to be avoided.

j) In addition to its inherent problems, the eye is also severely limited by environment. Optical properties of the atmosphere alter the appearance of aircraft, particularly on hazy days. 'Limited visibility' actually means 'reduced vision'. You may be legally VFR when you have 5 km visibility, but at that distance on a hazy day you may have difficulty in detecting opposing traffic; at that range, even though another aircraft may be visible, a collision may be **unavoidable** because of the high closing speeds involved. Consider flying above a haze layer if you can.

k) Light also affects our visual efficiency. Glare, usually worse on a sunny day over a cloud layer or during flight directly into the sun, makes objects hard to see and scanning uncomfortable. An aircraft that has a high degree of contrast against the background will be easy to see, while one with low contrast at the same distance may be impossible to see. In addition, when the sun is behind you, an opposing aircraft will stand out clearly, but if you are looking into the sun, the glare of the sun will often prevent you from seeing the other aircraft. A dirty, scratched, opaque or distorted windshield will make matters worse. Keep it clean, and if it has deteriorated, consider fitting a new windshield or using a proprietary refurbishing kit.

l) Another problem with contrast occurs when trying to sight an aircraft against a cluttered background. If the aircraft is between you and terrain that is varicoloured or heavily dotted with buildings, **it will blend into the background** until the aircraft is quite close.

m) In daylight, the colours and shapes are seen by ‘cones’ which are light-sensitive cells concentrated mainly in a small central area of the retina of the eye. In very low light conditions, the cones become inactive, and vision is taken over by 'rods' which make up the rest of the retina, and which are saturated by bright light. Rods cannot distinguish colour, they are not as good at distinguishing shapes as cones, and in darkness there is now an area in the centre of the retina (populated by inactive cones) which cannot see anything.

This explains why it is easier to see a faint star by looking away (by about 10 degrees) than straight at it. Rods take 30 minutes in the dark to reach their efficiency. They are insensitive to red light, so WWII night fighter pilots sat around in dim red rooms before jumping into dim red cockpits. Nowadays it is felt more important to interpret a normally lit instrument correctly than run the risk of misinterpreting a dim red instrument, even though the pilot's outside night vision might be better in the latter case. The view from the cockpit over most of the UK contains many external lights which can saturate the rods. However, it makes sense for pilots to try to avoid looking at bright lights at night. It is important to maintain a scan at night, but where the rods have had a chance to acclimatise, a continuous scan which will cause an image (aircraft lights) to move on the retina may be more effective than trying to focus on one area of sky (because the fine focusing cones are not working). Since the rods are sensitive to movement, they are more likely to be alerted by this technique.

n) Finally, there are the tricks that the mind can play, which can distract the pilot to the point of not seeing anything at all, or cause cockpit myopia — staring at one instrument without even 'seeing' it. At night, concentrating on a static light can make it appear to move.

o) It can be realised that visual perception is affected by many factors. Pilots, like others, tend to **overestimate their visual abilities** and to misunderstand their eyes' limitations. Since a major cause of mid-air collisions is the failure to adhere to the practice of see-and-avoid, it can be concluded that the best way to avoid collisions is to learn how to use your eyes for an efficient scan.

4 VISUAL SCANNING TECHNIQUE

a) To avoid collisions you must scan effectively from the moment the aircraft moves until it comes to a stop at the end of the flight. Collision threats are present on the ground, at low altitudes in the vicinity of aerodromes, and at cruising levels.

b) Before take-off, check the runway visually to ensure that there are no aircraft or other objects in the take-off area. Check the approach and circuit to be sure of the position of other aircraft. Assess the traffic situation from radio reports. After take-off, continue to scan to ensure that there will be no obstacles to your safe departure.

c) During the climb and descent beware of the blind spot under the nose – manoeuvre the aircraft so that you can check.

d) Especially during climb or descent, listen to radio exchanges between air traffic and other aircraft and form a mental image of the traffic situation and positions of aircraft on opposing and intersecting headings, anticipating further developments. Scan with particular care where traffic is 'funnelled' by terrain or controlled airspace and when near a radio beacon or VRP. You should remain constantly alert to all traffic within your normal field of vision, as well as periodically scanning the entire visual field outside the aircraft to ensure detection of conflicting traffic. Remember that the performance capabilities of many aircraft, in both speed and rates of climb/descent, result in high closure rates, limiting the time available for detection, decision, and evasive action.

5 HOW TO SCAN

a) The best way to develop effective scanning is by eliminating bad habits. Naturally, not looking out at all is the poorest scan technique! Glancing out at intervals of five minutes or so is also poor when considering that it takes only seconds for a disaster to happen. Check the next time the aircraft is climbing out or making an approach to see how long you spend without looking outside.

b) Glancing out and 'giving the old once-around' without stopping to focus on anything is practically useless; so is staring out into one spot for long periods of time.

c) There is no one technique that is best for all pilots. The most important thing is for each pilot to develop a scan that is both comfortable and workable.

d) Learn how to scan properly by knowing where and how to concentrate your search on the areas most critical to you at any given time. In the circuit especially, **always** look out before you turn to make sure your path is clear and that nothing is approaching from an area that will be hidden as you turn. Look out for traffic making an improper entry into the circuit.

e) During that very critical final approach stage, do not forget to scan all around to avoid tunnel vision. Pilots often fix their eyes on the point of touchdown. You may never arrive at the runway if another pilot is also aiming for the same runway threshold at that time!

f) In normal flight, you can generally avoid most of the risk of a mid-air collision by scanning an area at least 60° left and right of your intended flight path. Be aware that constant angle collisions often occur when the other aircraft initially appears motionless at about your 10 o'clock or 2 o'clock positions. This does not mean you should forget the rest of the area you can see. You should also scan at least 10° above and below the projected flight path of your aircraft. This will allow you to spot any aircraft that is at an altitude that might prove hazardous to you, whether it is level with you, climbing from below or descending from above.

g) The more you look outside, the less the risk of a collision. Certain techniques may be used to increase the effectiveness of the scan. To be most effective, the gaze should be shifted and refocused at regular intervals. Most pilots do this in the process of scanning the instrument panel but it is also important to focus outside the cockpit or flight deck to set up the visual system for effective target acquisition. Looking well ahead for weather and pre-planned navigation features can help. Proper scanning requires the constant sharing of attention with other piloting tasks, thus it is easily degraded by such conditions as distraction, fatigue, boredom, illness, anxiety or preoccupation.

h) Effective scanning is accomplished by a series of short, regularly-spaced eye movements that bring successive areas of the sky into the central visual field. Each movement should not exceed 10°, and each area should be observed for about one second to enable detection. Although horizontal back-and-forth eye movements seem preferred by most pilots, each pilot should develop the scanning pattern that is most comfortable and then keep to it. Peripheral vision can be useful in spotting collision risks. It is essential to remember, however, that if another aircraft appears to have no relative motion, it is likely to be on a collision course with you. If the other aircraft shows no horizontal or vertical motion on the windshield, but is increasing in size, **take immediate evasive action**.

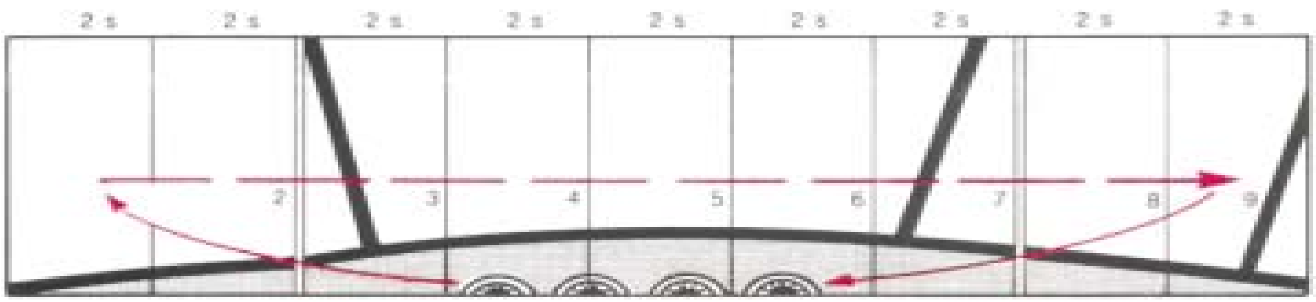
6 SCAN PATTERNS

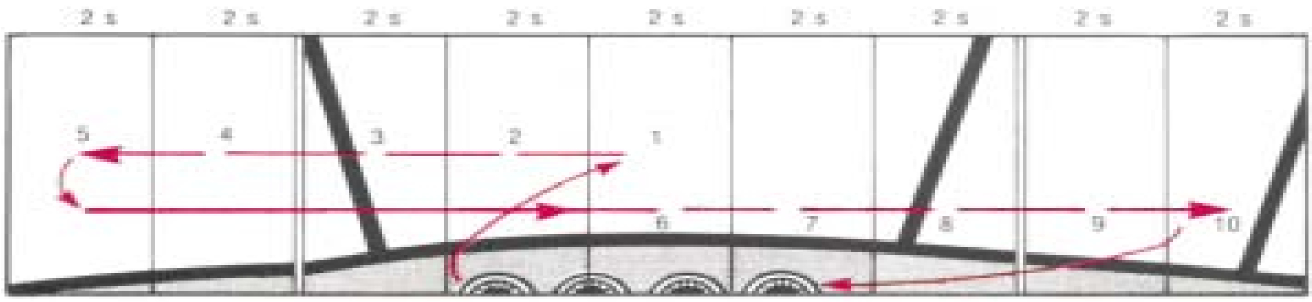
a) Two scanning patterns described below have proved to be very effective for pilots and involve the 'block' system of scanning. This system is based on the premise that traffic detection can be made only through a series of eye fixations at different points in space. In application, the viewing area (windshield) is divided into segments, and the pilot methodically scans for traffic in each block in sequential order.

i) *Side-to-side scanning method*
Start at the far left of your visual area and make a methodical sweep to the right, pausing very briefly in each block of the viewing area to focus your eyes. At the end of the scan, return to and scan the instrument panel and then repeat the external scan.

ii) *Front-to-side scanning method*
Start in the centre block of your visual field (centre of front windshield); move to the left, focusing very briefly in each block, then swing quickly back to the centre block after reaching the last block on the left and repeat the action to the right. Then, after scanning the instrument panel, repeat the external scan.

b) There are other methods of scanning, of course, some of which may be as effective as the two described above. However, unless some series of fixations is made, there is little likelihood that you will be able to detect all targets in your scan area. When the head is in motion, vision is blurred and the mind will not register potential targets.





7 THE TIME-SHARING PLAN

a) External scanning is just part of the pilot's total visual work. To achieve maximum efficiency in flight, a pilot also has to establish a good internal scan and learn to give each scan its proper share of time, depending, to some extent, on the work-load inside the cockpit and the density of traffic outside. Generally, the external scan will take considerably longer than the look at the instrument panel.

b) During an experimental scan training course, using military pilots whose experience ranged from 350 hours to over 4,000 hours of flight time, it was discovered that the average time they needed to maintain a steady state of flight was three seconds for the instrument panel scan and 18 to 20 seconds for the outside scan.

c) An efficient instrument scan is good practice, even when flying VFR. The ability to check gauges quickly and accurately permits more time to be allotted to exterior scanning, thus improving collision avoidance.

d) Developing an efficient time-sharing plan takes a lot of work and practice, but it is just as important as developing good landing techniques. The best way is to start on the ground, in your own aeroplane or the one you usually fly, and then use your scans in actual practice at every opportunity.

e) During flight, if one crew member is occupied with essential work inside the cockpit, another crew member, if available, must expand his scan to include both his usual sector of observation and that of the other crew member.

f) Pilots often find it difficult to maintain a good lookout scan for long periods. Pre-flight study can identify areas of your planned flight where the risk of collision is highest (see paragraph 9). Having noted these areas, you should consciously re-invigorate your scan when approaching them.

8 AIRPROX REPORTING

If you consider that your aircraft has been endangered during flight by the proximity of another aircraft such that a risk of collision existed, report it by radio to the Air Traffic unit with which you are in contact. Prefix the call 'AIRPROX'. If this is not possible, immediately after landing (in the UK) telephone or by other means contact any UK ATS unit, but preferably an ATCC. Prompt action is important. Confirm in writing within seven days using CA 1094 'Airprox Report Form', available from the UKAB.

9 OPERATIONAL TECHNIQUES

a) Collision avoidance involves more than proper scanning techniques. You can be the most conscientious scanner in the world and still have an in-flight collision if you neglect other important factors.

- **Check yourself**

Start with yourself - your safety depends on your mental and physical condition. A ‘pulled’ neck or back muscle can restrict head movement. If you are preoccupied you should not fly – absent-mindedness and distraction are the main enemies of concentrated attention during flight. Illness affects your eyes, as does age, so if you are a mature pilot have regular eye checks. If you need glasses to correct your vision, then wear them and ensure that you have the required spare pair with you.

- **Plan ahead**

Plan your flight carefully, and have charts folded in proper sequence and within reach. Reduce time with your head down in your charts by being familiar with headings, frequencies, distances, etc. Record these on a flight log before take-off. Looking well ahead for pre-planned navigation features helps focus your eyes at the correct distance. Lift anything you need to read up to the coaming, rather than look down; mature pilots may wish to consider ‘half-moon’ reading glasses for map details etc. Check your maps, NOTAM, etc. in advance for potential hazards such as military low-level routes and other high-density areas. See SafetySense Leaflet 18, ‘*Military Low Flying*’.

- **Clean windows**

During the pre-flight walk-around, make sure your windshield is clean and in good condition. If possible, keep all windows clear of obstructions such as opaque sun visors and curtains.

- **Night Flying**

Be aware of the limitations of vision at night and give your eyes time to adjust. Avoid blinding others with the careless use on the ground of your strobes or landing lights.

- **Adhere to procedures**

Follow established operating procedures and regulations, such as correct flight levels (quadrantal or semi-circular) and proper circuit practices. You can get into trouble, for instance, by 'sneaking' out of your proper level as cumulus clouds begin to tower higher and higher below you, or by skimming along the tops or base of clouds without observing proper cloud clearance. Typical hazardous situations around airports include: entering a right-hand circuit at an airport with left-hand traffic or entering downwind so far ahead of the circuit that you may interfere with traffic taking off and heading out in your direction. Beware of pilots flying large circuits with long final approaches. **In most in-flight collisions at least one of the pilots involved was not where he was supposed to be.**

- **Avoid crowded airspace**

Avoid crowded airspace, for example over a VRP or radio beacon, where aircraft may be training, even in good weather. If you cannot avoid aerodromes en route, fly over them well above ATZ height and if appropriate give them a call stating your intentions. If following a GPS track to a database waypoint, consider keeping to the right of the direct track, as you do for a line feature on the ground.

Gliders are not easy to see, and use the rising air under cumulus clouds and upwind of lenticular clouds.

The area around a glider launching site is also likely to be very busy, apart from the hazard of colliding with a launch cable up to its notified maximum height. Aeroplanes towing gliders are less manoeuvrable than individual aircraft.

Microlights climb steeply; beware when passing their sites.

- **Compensate for blind spots**

Compensate for your aircraft's design limitations. If you are short, or the aircraft has a high coaming, a suitable cushion can be helpful.

All aircraft have blind spots; know where they are in yours. For example, during a turn, the wing of a high-wing aircraft blocks the view of the area you are turning into, so lift the wing slightly for a good look **before turning**. In any aircraft, check the area <u>outside</u> your intended turn before entering – do not rely on others' lookout!

One of the most critical potential mid-air collision situations exists when a faster low-wing aircraft is overtaking and descending onto a high-wing aircraft on final approach.

- **Equip to be seen**

<u>Your aircraft lights</u> can help avoid collisions. High-intensity strobe lights, which can be installed at relatively low cost, increase your contrast and conspicuity a certain amount by day and even more by night. In areas of high traffic density, strobe lights are often the first indication another pilot receives of your presence. Consider the use of landing lights, especially in the traffic pattern and on hazy days.

<u>Transponders</u>, especially with altitude encoding (Mode C), allow radar controllers to identify your aircraft in relation to other traffic and provide you with traffic information.

They also highlight your aircraft's presence to other, mainly commercial, aircraft which carry ACAS (Aircraft Collision Avoidance System). If you show mode C, ACAS may be able to guide the other aircraft away from you! The carriage of transponders is now mandatory in some airspace, even when operating VFR. If ATC do not allocate you a code, use code 7000 (with Mode C), and only switch it off if instructed.

***Colour*.** Aircraft finished in one high contrast colour can be seen more easily than those with a pattern or one low contrast colour. Tests have shown that matt black (or gloss black) gives greatest contrast against sky.

- **Talk and listen**

Use your ears as well as your eyes by taking advantage of all the information that you receive over the radio (but beware, non-radio aircraft may be in the same airspace). Pilots reporting their position to the tower are also reporting to you. Approaching an aerodrome, call the tower when you are 10 km from the airport, or such other distance or time prescribed by the ATS authority, and report your position, height/altitude and intentions. En-route, make use of a Lower Airspace Radar Service if available (see SafetySense Leaflet 8 '*Air Traffic Services Outside Controlled Airspace*'). When flying in areas where there are no air traffic services, change to the FIR or nearest aerodrome frequency.

- **Make use of information**

Since detecting a small aircraft at a distance is not the easiest thing to do, make use of any hints you get over the radio. Your job is much (studies suggest eight times!) easier when you are told that traffic is "three miles at one o'clock". **Once that particular traffic is sighted, do not forget the rest of the sky**. If the traffic seems to be moving on the windshield, you're most probably not on a collision course, so continue your scan but watch the traffic from time to time. **If it has little relative motion you should watch it very carefully – he may not have seen you.**

- **Use all available eyes**

If you normally fly with another pilot, establish crew procedures which ensure that an effective scan is maintained at all times. Otherwise, use passengers to help in looking for traffic you have been made aware of, while you monitor the movement of other aircraft. Remember, however, that the responsibility for avoiding collisions is yours and you must maintain your vigilance at all times.

- **Scan**

The most important item, of course, is to keep looking out at where you are going and to watch for other traffic. Make use of your scan constantly.

b) Stick to good airmanship; if you keep yourself and your aircraft in good condition, plan your route carefully (including avoiding likely busy areas) and develop an effective scan time-sharing system, you will have the basic tools for avoiding a mid-air collision.

10 SUMMARY

- If you need glasses, carry any required spare pair.
- Clean the windshield and side windows (if either is badly scratched, have a new one fitted).
- If you are short or the aircraft has a high coaming, use a cushion.
- Plan your flight so you are looking ahead for expected features.
- Plan to avoid busy areas if possible.
- Beware of blind spots - move your head or manoeuvre the aircraft.
- Spend the minimum time with your head down checking the charts (or GPS), changing radio frequencies etc.
- The aircraft with little or no relative motion is the one which is hard to see – and the most hazardous.
- Aircraft below you may blend into the background of buildings etc.
- High-intensity strobes can be useful on dull days.
- Use LARS and other radio information to form a mental picture of what is going on. Don't rely solely on it – someone could be NON-RADIO.
- Develop and use an effective scan pattern.
- Don't move the eyes continuously; stop and give them a chance to SEE.
- The external scan should take much longer than your instrument scan.
- When you have spotted another aircraft, do not fix on it and forget the rest of the surroundings.
- Select 7000 with ALT on your transponder at all times unless told otherwise.
- Use landing lights in the circuit.
- Consider cruising above any haze layer.
- Encourage your passengers to assist in the look-out.
- Report any AIRPROX.